Total Maximum Daily Load

Evaluation

for

Mud Swamp Creek

Suwannee River Basin

(Fecal Coliform)

Submitted to:

The U.S. Environmental Protection Agency
Region 4
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Submitted by:
The Georgia Department of Natural Resources
Environmental Protection Division
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Table of Contents

List of Tables

List of Figures

Appendices

EXECUTIVE SUMMARY

The State of Georgia assesses its water bodies for compliance with water quality standards criteria established for their designated uses as required by the Federal Clean Water Act (CWA). Assessed water bodies are placed into three categories, supporting, partially supporting, or not supporting their designated uses depending on water quality assessment results. These water bodies are found on Georgia's 305(b) list as required by that section of the CWA that defines the assessment process, and are published in *Water Quality in Georgia* every two years.

Some of the 305(b) partially and not supporting water bodies are also assigned to Georgia's 303(d) list, also named after that section of the CWA. Water bodies on the 303(d) list are required to have a Total Maximum Daily Load (TMDL) evaluation for the water quality constituent(s) in violation of the water quality standard. The TMDL process establishes the allowable pollutant loadings or other quantifiable parameters for a water body based on the relationship between pollutant sources and in-stream water quality conditions. This allows water quality-based controls to be developed to reduce pollution and restore and maintain water quality.

The State of Georgia has identified Mud Swamp Creek in the Suwannee River basin as not meeting the water quality standard criteria for fecal coliform bacteria. The reach of water has a water use classification of fishing and a fecal coliform bacteria water quality standard as described below:

> For the months of May through October, fecal coliform not to exceed a geometric mean of 200 per 100 ml based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours. For the months of November through April, fecal coliform not to exceed a geometric mean of 1,000 per 100 ml based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours and not to exceed a maximum of 4,000 per 100 ml for any sample.

In 1998, fecal coliform bacteria data were collected at Mud Swamp Creek near Valdosta, Georgia (GAEPD site 09013001), to calculate four distinct geometric mean values. The results of these data indicated there were three exceedances of the fecal coliform geometric mean standards in 1998. At this site, two of the geometric mean values exceeded the fecal coliform water quality standard of 200 counts/ 100 ml (May – October) and one value exceeded the fecal coliform water quality standard of 1000 counts/100 ml (November-April). As a result, ten miles of Mud Swamp Creek from downstream of Valdosta to Alapahoochee River were added to the State's 303(d) list and scheduled for a TMDL evaluation.

The analysis performed to develop the TMDL for fecal coliform bacteria for Mud Swamp Creek used dynamic hydrologic and water quality modeling techniques that considered the characteristics of the watershed, meteorology, hydrology, and land use. The model used local meteorological data and local watershed and stream characteristics in the simulation. Land use in the watershed was characterized from 1995 land use data for the watershed. Land use activities contributing fecal coliform bacteria simulated using the model included septic tanks, cattle grazing, poultry operations, manure management, urban development, and wildlife. Model parameterization for urban, agricultural, and forested land uses were provided by the U.S. Environmental Protection Agency (EPA). National Pollutant Discharge Elimination System (NPDES) permitted discharges were also included in the modeling analysis. The modeling assumptions were considered conservative and provide the necessary implied margin of safety for the TMDL.

A simulation period of 10 years (1989 – 1998) was used to develop the fecal coliform bacteria TMDL. A critical 30-day period was identified during this 10-year period from which the TMDL could be developed. Data from 1998 were used to calibrate both the hydrologic and water quality models.

Point and non-point sources of fecal coliform bacteria were modeled. One permitted domestic wastewater treatment facilities that discharge into Mud Swamp Creek was included in the model. Load reductions were applied until the critical 30-day geometric mean of the in-stream fecal coliform bacteria counts did not exceed the water quality standard criteria. Reducing non-point source loading rates in the Mud Swamp Creek reduces in-stream fecal coliform bacteria levels. Modeling results indicate that an allocation scenario to meet in-stream water quality standards requires a 97% reduction in fecal loads from the Mud Swamp Creek watershed. Non-point sources related to land use activities (i.e., urban runoff) were found to have the most impact on the fecal coliform bacteria loadings in the Mud Swamp Creek watershed. Leaking septic and collection systems were considered secondary sources of fecal coliform.

Management practices that can be used to implement these TMDLs include controlling leaking collection and septic systems and urban runoff. In addition, adoption of NRCS resource management practices including covering manure and poultry litter stacks exposed to the environment; reducing animal access to streams; and applying manure to croplands at agronomical rates can also improve water quality. Best management practices (BMPs) should be developed to address urban and agricultural runoff during extreme storm events.

1.0 INTRODUCTION

1.1 Background

The State of Georgia assesses its water bodies for compliance with water quality standards criteria established for their designated uses as required by the Federal Clean Water Act (CWA). Assessed water bodies are placed into three categories, supporting, partially supporting, or not supporting their designated uses depending on water quality assessment results. These water bodies are found on Georgia's 305(b) list as required by that section of the CWA that defines the assessment process, and are published in *Water Quality in Georgia* every two years.

Some of the 305(b) partially and not supporting water bodies are also assigned to Georgia's 303(d) list, also named after that section of the CWA. Water bodies on the 303(d) list are required to have a Total Maximum Daily Load (TMDL) evaluation for the water quality constituent(s) in violation of the water quality standard. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and in-stream water quality conditions. This allows water quality based controls to be developed to reduce pollution and restore and maintain water quality.

The State of Georgia has identified a segment of Mud Swamp Creek in the Suwannee River basin as violating the water quality standard criteria for fecal coliform bacteria. In 1998, fecal coliform bacteria data were collected at Mud Swamp Creek near Valdosta, Georgia (GAEPD site 09013001) to calculate four distinct geometric mean values. At this site, there were three exceedances of the fecal coliform geometric mean standards in 1998. As a result, ten miles of Mud Swamp Creek from downstream of Valdosta to Alapahoochee River were added to the State's 303(d) list and scheduled for a TMDL evaluation.

1.2 Watershed Description

The Mud Swamp Creek watershed is located in the Suwannee River basin in southeastern Georgia, in Lowndes County (See Figure 1). Mud Swamp Creek is a tributary to the Alapahoochee River. The total area of the Mud Swamp Creek watershed is approximately 43 square miles.

The land use characteristics of the Mud Swamp Creek watershed were determined using data from Georgia's Multiple Resolution Land Coverage (MRLC). This coverage is based on Landsat Thematic Mapper digital images developed in 1995. The classification is based on a modified Anderson level one and two system. Table 1 lists the land use distribution in the watershed. The data show that the watershed is predominately forested (50 percent) with the next predominate land use being urban (27 percent) and the rest being a mixture as shown in Figure 2.

Table 1. Land Use Distribution

Land Use	Watershed Mud Swamp Creek	
	Acres	Percent
Bare Rock/Sand/Clay	14	0.1
Deciduous Forest	349	1.3
Deciduous Shrubland	59	0.2
Emergent Herbaceous Wetlands	1133	4.1
Evergreen Forest	4077	14.8
Grassland/Herbaceous	288	1.0
High Intensity Commercial/Industrial/Transportation	852	3.1
High Intensity Residential	973	3.5
Low Intensity Residential	3366	12.2
Mixed Forest	1792	6.5
Open Water	63	0.2
Other Grasses (Urban/recreational; e.g. parks, lawns	578	2.1
Pasture/Hay	518	1.9
Planted/Cultivated (orchards, vineyards, groves)	161	0.6
Row Crops	5620	20.4
Transitional	2199	8.0
Woody Wetlands	5516	20.0
Total	27558	100.0

1.3 Water Quality Standard

The water use classification for Mud Swamp Creek is fishing. The fishing classification water quality standard for fecal coliform bacteria as stated in Georgia's Rules and Regulations for Water Quality Control Chapter 391-3-6-.03(6)(c) is:

(c) Fishing: Propagation of Fish, Shellfish, Game and Other Aquatic Life; secondary contact recreation in and on the water; or for any other use requiring water of a lower quality:

(iii) Bacteria: For the months of May through October, when water contact recreation activities are expected to occur, fecal coliform not to exceed a geometric mean of 200 per 100 ml based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours. Should water quality and sanitary studies show fecal coliform levels from non-human sources exceed 200/100 ml (geometric mean) occasionally, then the allowable geometric mean fecal coliform shall not exceed 300 per 100 ml in lakes and reservoirs and 500 per 100 ml in free flowing freshwater streams. The months of November through April, fecal coliform not to exceed a geometric mean of 1,000 per 100 ml based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours and not to exceed a maximum of 4,000 per 100 ml for any sample. The State does not encourage swimming in surface waters since a number of factors, which are beyond the control of any State regulatory agency, contribute to elevated levels of fecal coliform. For waters designated as approved shellfish harvesting waters by the appropriate State agencies, the requirements will be consistent with those established by the State and Federal agencies responsible for the National Shellfish Sanitation Program. The requirements are found in the National Shellfish Sanitation Program Manual of Operation, Revised 1988, Interstate Shellfish Sanitation Conference, U.S. department of Health and Human Services (PHS/FDA), and the Center for Food Safety and Applied Nutrition. Streams designated as generally supporting shellfish are listed in Paragraph 391-3-6-.03(14).

2.0 WATER QUALITY ASSESSMENT

Water quality monitoring data were collected from Mud Swamp Creek near Valdosta, Georgia during 1998. Table 2 lists the fecal coliform bacteria data results at this site, as well as computed geometric mean values. Four discrete samples were collected and analyzed within a 30-day period in order to compute the geometric mean values. These data results were compared with the fecal coliform bacteria water quality standard to assess compliance.

Table 2: Water Quality Monitoring Data

Date	Mud Swamp Creek near Valdosta Fecal Coliform Bacteria (MPN/100 ml)	Geometric Mean
1/20/98	170	
02/02/98	2400	
02/09/98	790	
02/17/98	3500	1031
05/07/98	7900	
05/14/98	330	
05/21/98	80	
05/28/98	330	512
08/27/98	330	
09/13/98	330	
09/17/98	490	
09/24/98	80	256
11/19/98	230	
12/03/98	490	
12/10/98	490	
12/17/98	50	229

These data show violations of the fecal coliform water quality standards for three geometric mean values. Two of the geometric mean values exceeded the fecal coliform water quality standard of 200 counts/ 100 ml (May- October) and one value exceeded the fecal coliform water quality standard of 1000 counts/100 ml (November-April).

3.0 SOURCE ASSESSMENT

A source assessment characterizes the known and suspected sources of fecal coliform bacteria in the watershed for use in the water quality model, and the development of the TMDL. The general sources of fecal coliform bacteria are point and non-point sources. National Pollutant Discharge Elimination System (NPDES) permittees discharging treated domestic waste are the primary point sources of fecal coliform bacteria.

Non-point sources of fecal coliform bacteria are diffuse sources that cannot be identified as entering the water body at a single location. These sources generally involve land activities that contribute fecal coliform bacteria to streams during a rainfall runoff event. Non-point sources of fecal coliform bacteria considered in the analysis include:

- Wildlife,
- Land application of agricultural manure,
- Grazing animals,
- Leaking septic systems,
- Leaky collection systems, and
- Urban development.

For non-point sources involving agricultural activities, the Natural Resources Conservation Service (NRCS) was consulted for information and parameters to be used to characterized agricultural activities represented in the water quality model

3.1 Point Source Assessment

There is one permitted NPDES discharge in the Mud Swamp Creek watershed upstream from the listed segment. This facility is the Valdosta WPCP (NPDES GA0020222), which has a permitted flow rate of 3.22 million gallons per day (MGD). The NPDES permit for this facility requires end-of-pipe criteria equivalent to the water quality standard of 200 counts/100 ml. This facility discharges into Mud Swamp Creek.

3.2 Non-point Source Assessment

3.2.1 Wildlife

Wildlife deposit fecal coliform bacteria with their feces onto the land where it can be transported during a rainfall runoff event to nearby streams. In the water quality model, the wildlife fecal coliform contribution is accounted for in the deer population input parameter. The deer population is estimated to be 30 to 45 animals per square mile in this area (personal communication, NRCS and Georgia Wildlife Resource Division State Deer Biologist, November 1999). The upper limit of 45 deer per square mile has been chosen to account for deer and all other wildlife present in the watershed. It is assumed that the wildlife population remains constant throughout the year, and that wildlife is uniformly distributed on all land classified in the MRLC database as forest, pasture, cropland, and wetlands.

3.2.2 Land Application of Agricultural Manure

Processed agricultural manure from confined hog, dairy cattle, and poultry operations is generally collected in lagoons and applied to land surfaces during the months April through October. Hog manure is applied only to cropland. NRCS estimates that 75 percent of cattle manure and poultry litter is applied to cropland and 25 percent is applied to pasture land. Manure application rates are included in Appendix A.

Data sources for confined feeding operations include the 1997 Census of Agriculture. Table 3 shows animal distribution in the watershed. The livestock data are also based on the 1997 Census of Agriculture and are reported by county. The county data are distributed to the watershed based on the percentage of agricultural area classified as pasture/hay. Cattle numbers reported in the census data also represent other breeds of cattle and calves besides dairy and beef.

Table 3. Livestock Distribution

Livestock	Mud Swamp Creek near Valdosta (individuals)
Beef Cow	152
Milk Cow	-
Cattle	304
Chickens	2
Chickens Sold	-
Hogs	219
Sheep	0

Hog farms in the watershed operate by confining the animals or allowing them to graze in small pastures or pens. It is assumed that all of the hog manure produced by either farming method is applied evenly to available cropland. Application rates of hog manure to pasture land vary monthly according to management practices.

In dairy farms, the cows are confined for a limited period each day, during which time they are fed and milked. This is estimated to be four hours per day for each dairy cow. The percentage of manure collected during confinement is applied to the available pasture and cropland in the watershed. Application rates of dairy cow manure to pasture and cropland vary monthly according to management practices.

3.2.3 Grazing Animals

Cattle, including beef and dairy, and hogs, spend time grazing on pasture land and depositing feces onto the land. During a rainfall runoff event, a portion of this material containing fecal coliform bacteria is transported to streams. Beef cattle spend all their time in pasture, while dairy cattle and hogs are confined periodically. The percentage of feces deposited during grazing time is used to estimate the fecal coliform loading rates from pasture land.

In addition, cattle and other unconfined animals often have direct access to streams that pass through pastures. Feces deposited in streams by grazing animals are included in the water quality model as a point source having constant flow and concentration. To calculate the amount of bacteria introduced into streams by cattle, it is assumed that only the beef cow population have access to the streams and of those approximately 12 percent will defecate in the stream (personal communication, EPA, NRCS, University of GA, Georgia Agribusiness Council, et al).

3.2.4 Leaking Septic Systems

Table 4 shows estimates from county census data of the number of septic systems in the watershed. In south Georgia, EPA estimates that there are approximately 2.37 people per household on septic systems. For modeling purposes, it is assumed that 20 percent of the septic systems in the watershed leak. Leaking septic systems are included in the water quality model as a point source having constant flow and concentration.

Table 4. Septic Systems

Watershed	Septic Systems
Mud Swamp Creek near Valdosta	1042

3.2.5 Urban Development

Fecal coliform bacteria from urban areas may originate from various sources including runoff through storm water sewers (e.g., residential, commercial, industrial, and road transportation), illicit discharges of sanitary waste, and runoff from improper disposal of waste materials. Overflowing sanitary sewers and leaking collection lines are not considered a significant source of fecal coliform bacteria in the Mud Swamp Creek watershed. Leaking collection lines are considered a potential source of fecal coliform bacteria in the Mud Swamp Creek watershed. To estimate the load of fecal coliform bacteria from leaking sewer collection lines, it is assumed that 2.5 percent of the permitted design flow of the municipal water pollution control plant (WPCP) is lost through leaks. The average fecal coliform bacteria concentration in the wastewater is 10,000 counts/100 ml (Horsley & Whitten, 1996).

4.0 MODELING APPROACH

Establishing the relationship between the in-stream water quality and the source loadings is an important component of TMDL development. It provides for both the identification of sources, and their relative contribution, as well as the examination of potential water quality changes resulting from varying management options to meet the water quality standard. This relationship can be developed using a variety of techniques ranging from simple methods based on scientific principles to more complex numerical computer modeling techniques. In this section, the numerical modeling techniques developed to simulate fecal coliform fate and transport in the watershed are discussed.

4.1 Model Selection

A dynamic water quality computer modeling approach was selected for the fecal coliform bacteria TMDL evaluation in order to satisfy a variety of objectives. The first objective is to simulate the time varying behavior of fecal coliform bacteria deposition on the land surface and transport to receiving water bodies. The second objective was to use a continuous simulation period to identify the critical conditions from which to develop the TMDL. Finally, the continuous simulation model provides the means to incorporate seasonal effects on the production and fate of fecal coliform bacteria. A series of computer-based tools were used to accomplish these objectives.

First, the Watershed Characterization System (WCS – developed by EPA and Tetra Tech), a geographic information system (GIS) tool, was used to display and analyze GIS information including land use, land type, point source discharges, soil types, population, and stream characteristics. The WCS was used to identify and summarize the sources of fecal coliform bacteria in the watershed, as well as the other factors that affect its fate and transport.

Information collected using WCS was used in a series of spreadsheet applications designed to compute fecal coliform bacteria loading rates in the watershed from varying land uses including urban, agricultural, and forestry as described in Section 3.0. Computed loading rates were used in a dynamic hydrologic and water quality model, NPSM (Non-Point Source Model), to simulate the deposition and transport of fecal coliform bacteria, and the resulting water quality response. The NPSM program uses the Hydrologic Simulation Program Fortran (HSPF) to simulate non-point source runoff, as well as the transport and flow of pollutants in stream reaches. A necessary feature of NPSM is its ability to integrate both point and non-point sources of fecal coliform bacteria and determine the in-stream water quality response.

4.2 Model Set Up

The Mud Swamp Creek watershed was delineated in order to characterize the relative fecal coliform bacteria contributions from the significant contributing land uses (see Figure 1). Watershed delineation was based on the RF3 stream coverage and elevation data.

The initial model set up used default parameters for the hydrologic and water quality simulation models that were considered appropriate for the south Georgia region. The model simulation used an hourly time interval and results were reported on a daily basis. During the model calibration process described later, some parameters were adjusted to improve model calibration.

A continuous simulation period from January 1, 1985, to December 31, 1998, was used in the analysis. The period from January 1, 1985, to December 31, 1988, was used to allow the model results to stabilize. The period from January 1, 1989, to December 31, 1998, was used to identify the critical conditions period from which to develop the TMDL. Since field data were collected during the period January 1, 1998 to December 31, 1998, this period was used for model calibration.

An important factor affecting the hydrologic and water quality model is the precipitation data contained in the meteorological data file used in the Mud Swamp Creek watershed simulation. The temporal distribution and intensity of rainfall affects the build-up and wash-off of fecal coliform bacteria from the land into the streams, as well as the dilution potential of the stream. Data from the Valdosta, Georgia, meteorological station were used in the model simulation.

4.3 Fecal Coliform Bacteria Source Representation

Both point and non-point sources of fecal coliform bacteria are represented in the water quality model. Because of varying decay or die-off rates for fecal coliform bacteria, and varying transport assumptions, the fecal coliform bacteria loadings from these sources are computed separately. The following sections describe the assumptions used for the various sources described in Section 3.0. Appendix A contains the worksheets (developed by EPA and Tetra Tech) used to compute the loading rates used in the model.

4.3.1 NPDES Discharge

The NPDES discharge into the Mud Swamp Creek watershed was represented in the water quality model by a constant flow and fecal coliform bacteria concentration. A discharge flow rate equal to Valdosta's permitted flow rate of 3.22 MGD was used. The fecal coliform bacteria concentration equal to the water quality standard of 200 counts/100 ml was used. The existing permitted load from this NPDES point source discharge is 7.33×10^{11} counts/ 30 days.

4.3.2 Wildlife

Fecal coliform contributions from wildlife are represented in the model based on deer population input parameter. In the model, deer, and consequently other wildlife, are uniformly distributed to forest, pasture, cropland, and wetland areas at a density of 45 deer per square mile. The assumed loading rate from wildlife is 5.0×10^{8} counts/animal/day. This is based upon best professional judgment.

4.3.3 Land Application of Agricultural Manure

Fecal coliform accumulation and build-up rates resulting from the land application of hog and cattle manure and poultry litter are represented using monthly input values. For modeling purposes it is assumed that a typical poultry farmer produces 5.5 batches of chickens per year. Therefore, the number of chickens on a farm at any one time is about one-fifth the number shown in Table 3. The animal fecal loading rates are: 1.24×10^{10} counts/day/hog (NCSU, 1994); 1.06×10^{11} counts/day/cow (NCSU, 1994); and 1.38×10^{8} counts/day/chicken (NCSU, 1994).

4.3.4 Grazing Animals

Beef and dairy cows in the watershed contribute feces containing fecal coliform bacteria directly to pastures during grazing. Because there is no monthly variation in animal access to pastures in south Georgia, the fecal loading rates to pasture land does not vary significantly throughout the year.

4.3.5 Urban Development

Urban land use represented in the MRLC database includes areas classified as: high intensity commercial, industrial, transportation, low intensity residential, high intensity residential, and transitional. A single, area-weighted loading rate from urban areas is used in the model and is based on the percentage of each urban land use type in the watershed and build-up and accumulation rates referenced in Horner (1992). Leaking collection lines are also considered a potential source of fecal coliform bacteria in the Mud Swamp Creek watershed. To estimate the load of fecal coliform bacteria from leaking sewer collection lines, it is assumed that 2.5 percent of the permitted design flow of the municipal water pollution control plant (WPCP) is lost through leaks. The average fecal coliform bacteria concentration in the wastewater is 10,000 counts/100 ml (Horsley & Whitten, 1996).

4.4 Model Calibration

Model calibration involves both hydrologic and water quality components. The hydrologic calibration is performed first, and involves comparing model simulated streamflows to estimated historic streamflow using data from a representative U.S. Geological Survey (USGS) stream gaging station for the same period of time. Calibration of the hydrologic model involved adjusting model parameters (e.g., evapotranspiration, infiltration, upper and lower zone storage, groundwater storage and recession, and interflow discharge) used to represent the hydrologic cycle, until an acceptable agreement was achieved between simulated and observed streamflows. There is no streamflow gage in the Mud Swamp Creek watershed. The USGS streamflow gage on the Alapaha River at Statenville, Georgia (USGS 02317500), in the Suwannee River basin, was used to calibrate the hydrologic model. Mud Swamp Creek historic streamflow was calculated by multiplying the gaged Alapaha River streamflow data by the ratio of the two watershed drainage areas. Results of the hydrology calibration are shown in Figures 1-3 in Appendix B.

The only fecal coliform bacteria data available for Mud Swamp Creek watershed were those data collected during 1998. These data were used to calibrate the water quality model. Calibrating the water quality model involved adjusting model parameters until an acceptable agreement was achieved between the simulated and measured data. A comparison of simulated water quality concentrations and observed concentrations for sampling stations in the watershed are included in Appendix B.

The predicted daily fecal coliform bacteria results compared well with the measured data. However, the computed 30-day geometric mean values did not necessary agree with the measured 30-day geometric mean values. This may be attributed to the difference between the calculation methods used to compute the geometric mean for the model data and that for the measured data. The model calculated the 30-day geometric mean based on 30 values. Whereas, only four measured values were used to calculate the 30-day geometric mean for the measured data. As a result, the geometric means computed using 30 values tends to be lower, since they are not as highly influenced by high values. The geometric means computed based on four values are much more sensitive to high values.

The results for the calibrated model are considered to represent existing conditions in the Mud Swamp Creek watershed. Therefore, the calibrated model was used to: select the critical period, develop the TMDL, and determine the loading reductions.

4.5 Critical Conditions

Critical conditions for non-point fecal coliform sources are an extended dry period followed by a rainfall runoff event. During the dry weather period, fecal coliform bacteria to build up on the ground and when is rains, it is washed off the ground by rainfall runoff. Critical conditions for point sources occur during low streamflows and corresponding reduced dilution potential. Both conditions are simulated in the NPSM model.

The ten-year simulation period from January 1, 1989, to December 31, 1998, was used to identify the critical conditions from which to base the fecal coliform bacteria TMDL. This 10-year period contained a range of hydrological conditions including low and high streamflows. The range of hydrological conditions provided an opportunity to identify the fecal coliform bacterial critical conditions period, as well as the amount of in-stream fecal coliform bacteria in the stream that can be used to develop the TMDL.

4.6 Allocation Model

The calibrated model was used as the basis for developing the allocation scenario for the TMDL. In order to reduce the fecal coliform loading from non-point source, NRCS recommended parameters were used in the allocation model to represent the implementation of best management practices in the watershed. In addition, the loading rates from urban land, septic tanks, leaky collection systems, and animal access to stream were also reduced. The results of the allocation model were compared to the calibrated model to determine the resulting reduction in fecal coliform loading from the watershed.

5.0 MODEL RESULTS

5.1 Existing Conditions

Model results indicate that the primary source of fecal coliform bacteria contamination in the Mud Swamp Creek watershed is from non-point source. These sources may include leaky collection and septic systems and urban runoff. In addition, the application of agricultural manure, grazing animals, and wildlife may also contribute to fecal coliform bacteria contamination in the Mud Swamp Creek watershed.

Figure 3 shows the 30-day geometric mean model results over the ten-year model simulation period for the existing conditions. This figure shows that the 30-day geometric mean of 200 counts/100 ml was exceeded several times, with the longest duration of exceedances occurring in 1993. Figure 4 shows the November through April fecal coliform standard maximum of 4000 counts/100 ml was also exceeded one time in the stream during the 10-year simulation period.

5.2 Critical conditions

Using the results of the ten-year 30-day geometric mean simulation for existing conditions, the 30-day critical period was determined. This period was the 30-day period with the greatest exceedances of the 30-day geometric mean standard (EPA, 1991). Meeting the water quality standards during this time period would mean that water quality standards could be met during the entire ten-year period. For the listed segments in the Mud Swamp Creek watershed, the highest violation of the 30-day geometric mean occurred during the period from August 26,1993, through September 24, 1993.

5.3 Allocation Model

The allocation model was developed using parameters representing the implementation of best management practices, which include repairing leaking collection and septic systems and controlling urban runoff. In addition, adoption of NRCS resource management practices will also improved water quality. These practices include covering manure and poultry litter stacks exposed to the environment; reducing animal access to streams; and applying manure to croplands at agronomical rates.

Results from the allocation model show no exceedances of either the 30-day geometric mean of 200 counts/100 ml or the November through April maximum of 4,000 per 100 ml for any sample (see Figures 3-4). The allocation model results show a 97% reduction in fecal loads in Mud Swamp Creek watershed during the 30-day critical period as a result of using parameters representing the implementation of best management practices.

Table 5 compares the existing load to the proposed allocated load for the TMDL.

Table 5. Existing and Allocated Fecal Coliform Bacteria Loads

Watershed ID	Existing Load (counts / 30 days)	Allocated Load (counts / 30 days)	Percent Reduction
Mud Swamp Creek near Valdosta	4.78×10^{13}	1.33×10^{12}	97

Valdosta			

6.0 ALLOCATION

6.1 Total Maximum Daily Load

A TMDL is the sum of the individual waste load allocations (WLA) for point sources and load allocations (LA) for non-point sources and natural background (40 CFR 130.2). The sum of these components may not result in an exceedance of water quality standards for that water body. To protect against exceedances, the TMDL must also include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the water quality response of the receiving water body. Conceptually, a TMDL can be expressed as follows:

$$\text{TMDL} = \Sigma\text{WLAs} + \Sigma\text{LAs} + \text{MOS}$$

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body while maintaining water quality standards. TMDLs establish allowable pollutant loadings that are less than or equal to the TMDL, and thereby provide the basis to establish water quality based controls. For some pollutants, TMDLs are expressed on a mass loading basis (e.g., pounds per day). For fecal coliform bacteria, the TMDL are expressed as counts per 30 days. Therefore, the TMDL represents the maximum fecal coliform bacteria load that can be assimilated by the stream during a selected critical 30-day period while maintaining the fecal coliform bacteria water quality standard of 200 counts/100 ml.

The total maximum daily load of fecal coliform bacteria was determined by adding the WLA and the LA. The MOS (as described in Section 6.5) was implicitly included in the TMDL analysis and does not factor directly in the TMDL equation as shown above. Table 6 shows the computation of the total maximum daily load using the WLAs and the LAs for the critical conditions.

Table 6. TMDL Components (counts/30 days)

Watershed ID	WLA (counts/30 days)	LA (counts/30 days)	MOS (counts/30 days)	TMDL (counts/30 days)
Mud Swamp Creek near Valdosta	7.33×10^{11}	5.98×10^{11}	Implicit	1.33×10^{12}

The following sections describe the various TMDL components and the TMDLs are summarized in Appendix C.

6.2 Waste Load Allocations

There is one permitted NPDES discharge in the Mud Swamp Creek watershed upstream from the listed segment. This facility is the Valdosta WPCP (NPDES GA0020222), which has a permitted flow rate of 3.22 million gallons per day (MGD). The NPDES permit for this facility requires end-of-pipe criteria equivalent to the water quality standard of 200 counts/100 ml.

The WLA for this facility was determined using the facility's permitted flow rate and the water quality standard criteria of 200 counts/100 ml. Therefore, the WLA for the Valdosta WPCP is 7.33×10^{11} counts per 30 days. Future facility NPDES permits will require end-of-pipe criteria equivalent to the water quality standard of 200 counts/100 ml.

6.3 Load Allocations

The non-point fecal coliform bacteria sources in the model have two transportation modes. First, animals in the stream and leaking collection and septic systems are modeled as direct sources to the stream. The other non-point sources result from fecal coliform bacteria that are applied to land. Fecal coliform applied to land is subject to a die-off rate and an absorption rate before it is transported to the stream.

Model results indicate that non-point sources have the most impact on the fecal coliform bacteria loadings in the Mud Swamp Creek watershed. Leaking collection and septic systems are considered secondary sources of fecal coliform.

Management practices that could be implemented to achieve this TMDL include repair of leaking collection and septic systems and control of stormwater runoff from urban areas. Best management practices (BMPs) should be developed to address urban runoff. In addition, adoption of NRCS resource management practices, which including covering manure and poultry litter stacks exposed to the environment; reducing animal access to streams; and applying manure to croplands at agronomical rates could also improve water quality. Additional monitoring and characterization of the watershed could be conducted to determine the existence of any unknown sources of fecal coliform bacteria in the watershed.

6.4 Seasonal Variation

Seasonal variability was incorporated in the continuous simulation water quality model by using varying monthly loading rates and daily meteorological data. The combination of a continuous simulation with varying loading rates and meteorological conditions incorporates seasonal variation in the analysis.

6.5 Margin of Safety

The MOS is a required component of TMDL development. There are two basic methods for incorporating the MOS: 1) Implicitly incorporate the MOS using conservative model assumptions to develop allocations; or 2) Explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. For this TMDL the MOS was implicitly incorporated in the use of conservative modeling assumptions.

7.0 RECOMMENDATIONS

7.1 Monitoring

GAEPD has adopted the basin approach to water quality management; an approach that divides Georgia's major river basins in to five groups. During each annual cycle, GAEPD's water quality monitoring resources are concentrated in one of the basin groups. One goal is to continue to monitor 303d listed waters. Those watersheds identified as having both urban and agricultural activities, microbial source tracking may be used in the future to clarify the specific sources of fecal coliform bacteria. During the next monitoring cycle in the south Georgia river basins, water quality monitoring in the Mud Swamp Creek watershed will help further characterize water quality conditions resulting form the implementation of management practices in the watershed. Additional characterization may be needed in the watershed to clarify the unknown sources of fecal coliform bacteria.

7.2 Point and Non-point Source Approaches

Permitted discharges will be regulated through the NPDES permitting process described in this report. Georgia is working with local governments, agricultural, and forestry agencies such as the Natural Resources Conservation Service, the Georgia Soil and Water Conservation Commission, and the Georgia Forestry Commission to foster the implementation of best management practices to address non-point sources. In addition, public education efforts will be targeted to individual stakeholders to provide information regarding the use of best management practices to protect water quality.

7.3 Public Participation

A thirty-day public notice will be provided for this TMDL. During this time the availability of the TMDL will be public noticed, a copy of the TMDL will be provided as requested, and the public will be invited to provide comments on the TMDL.

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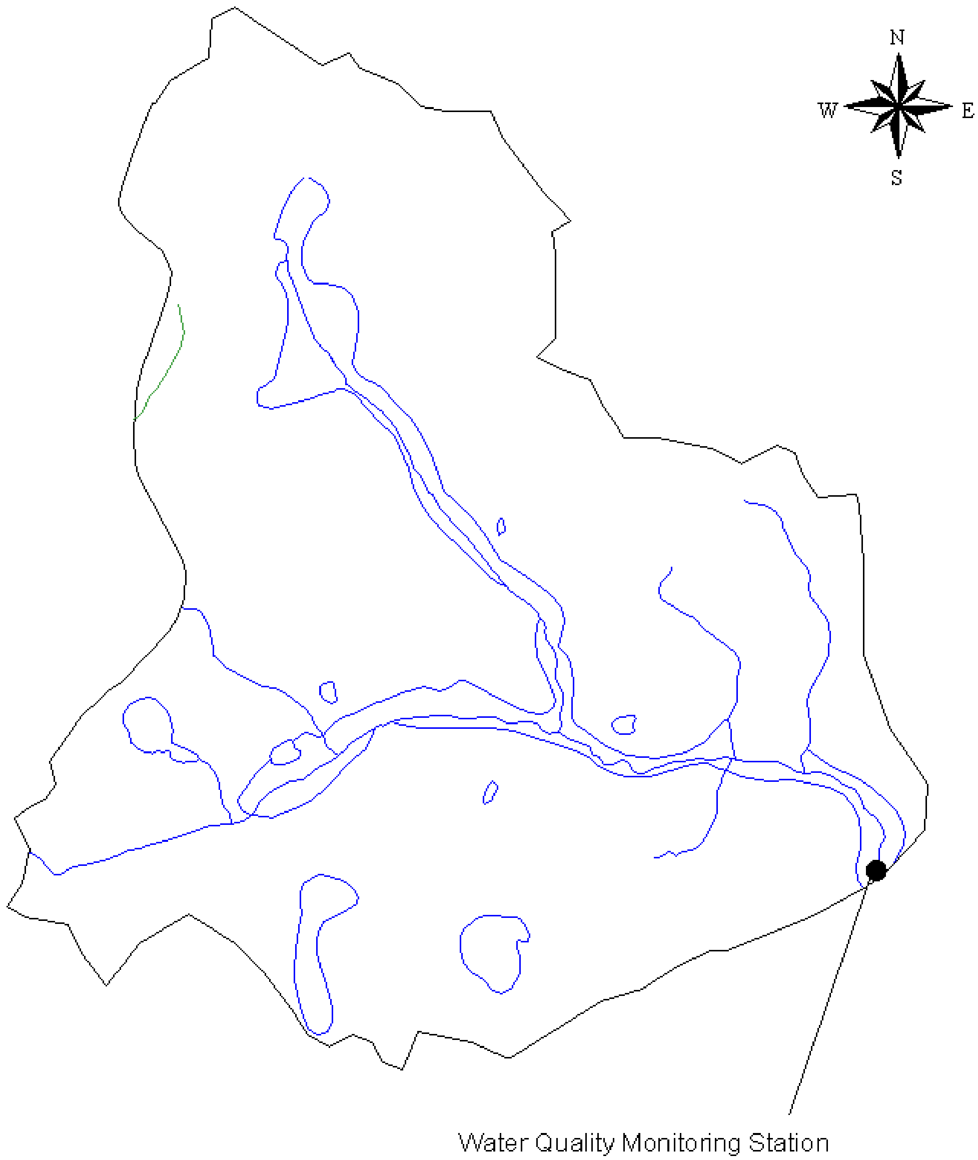
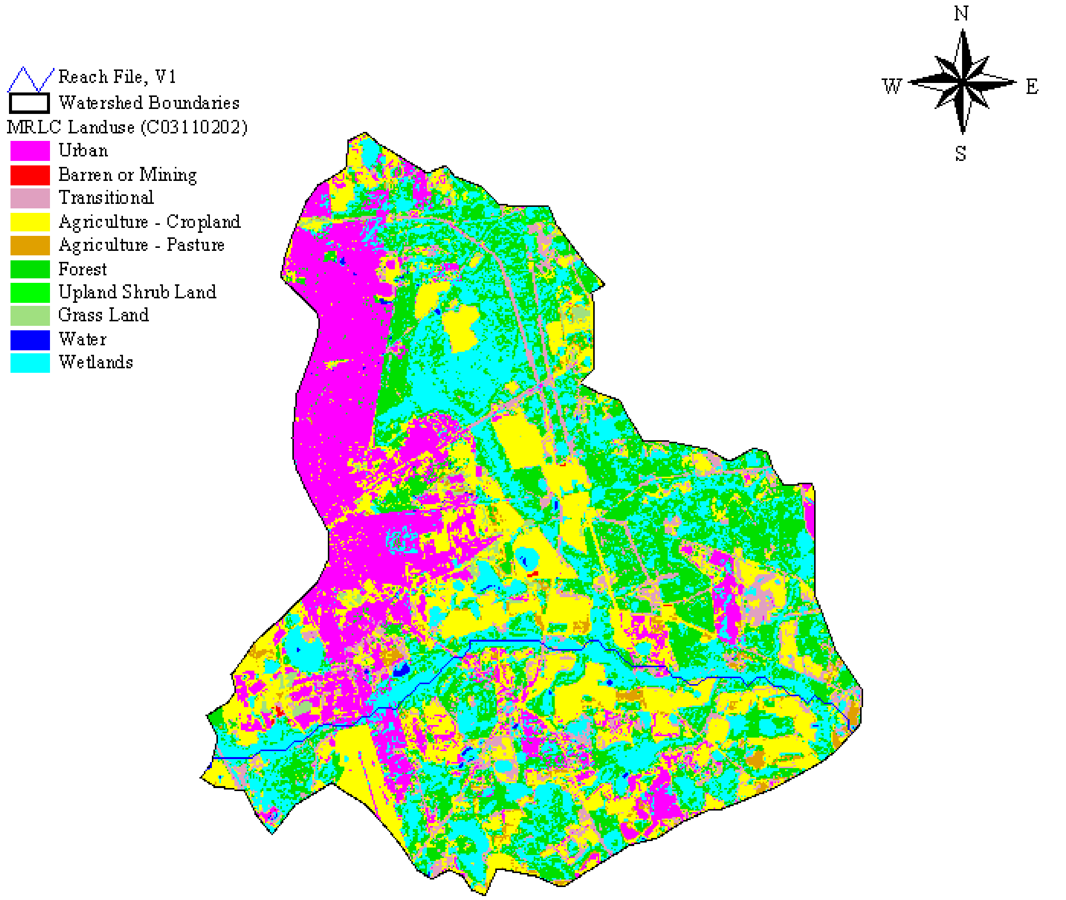


Total Maximum Daily Load (Fecal Coliform)
Mud Creek Watershed
June 2000

Georgia Department of Natural Resources
Environmental Protection Division
Atlanta, Georgia

Figure 1
Mud Swamp Creek Watershed



Total Maximum Daily Load (Fecal Coliform)
Mud Creek Watershed
June 2000

Georgia Department of Natural Resources
Environmental Protection Division
Atlanta, Georgia

Figure 2
Mud Swamp Creek Watershed
Land Use Distribution

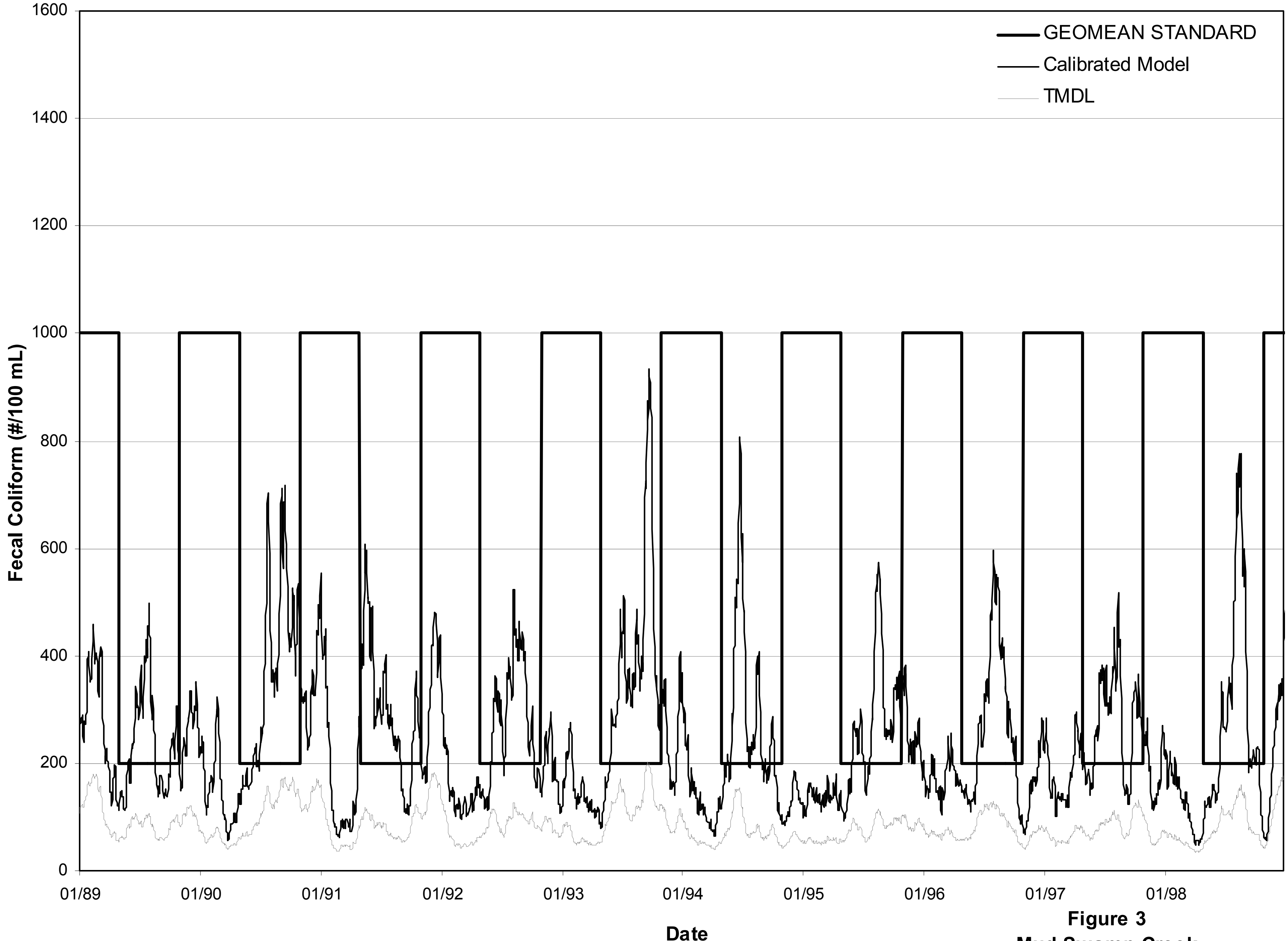


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Figure 3
Mud Swamp Creek
30-Day Geometric Mean
Fecal Coliform Model Results

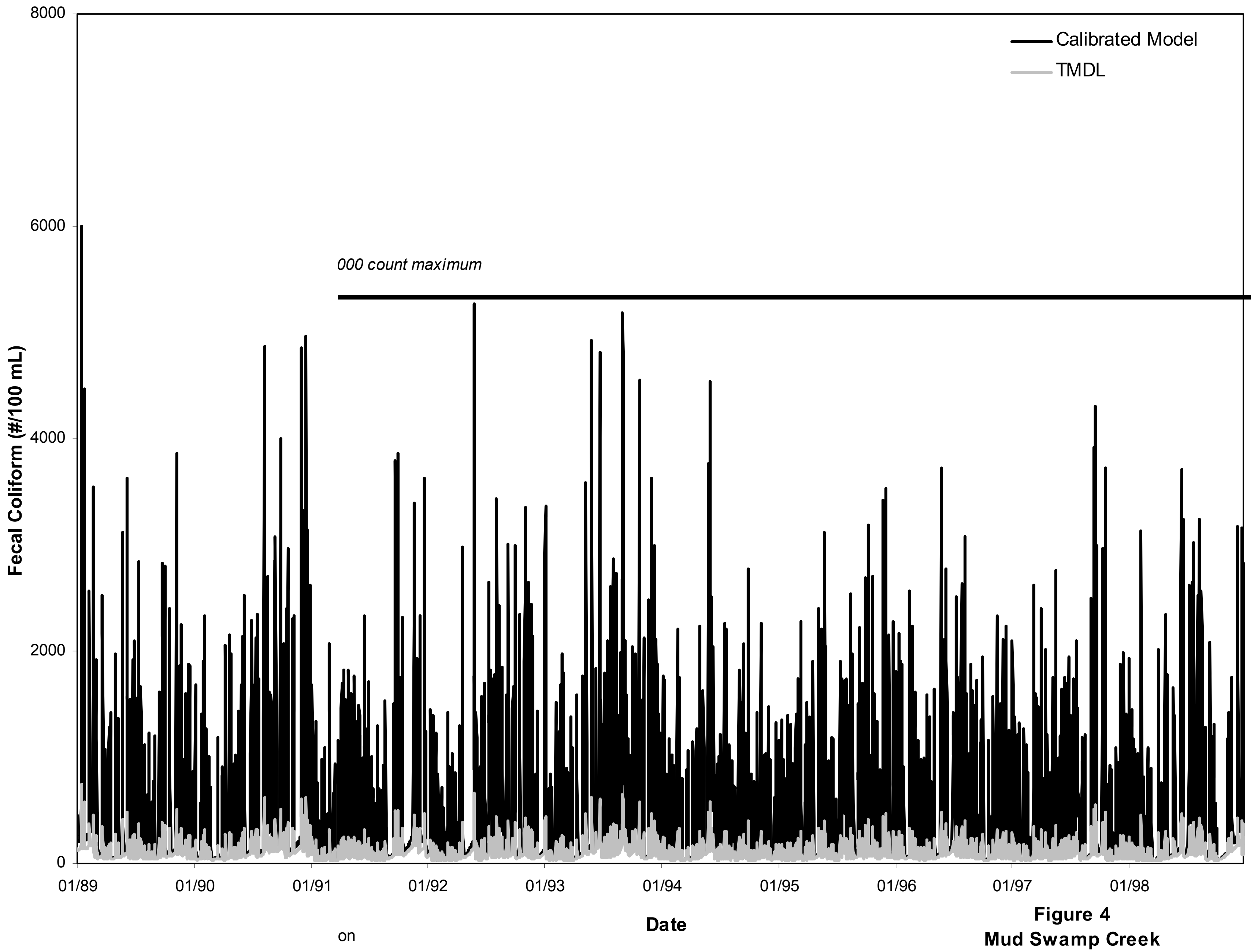


Figure 4
Mud Swamp Creek
Daily Fecal Coliform Model Results

APPENDIX A

Water Quality Model Loading Parameters For TMDL Scenario

Total Maximum Daily Load Evaluation (Fecal Coliform)
Mud Swamp Creek Watershed

Land Use Fecal Coliform Accumulation Rates and Storage Limits

ACQOP and SQOLIM by Landuse

This sheet contains values for ACQOP (or MON-ACCUM if monthly) and SQOLIM (or MON-SQOLIM if monthly). These parameters represent the rate of fecal coliform accumulation and the maximum storage of fecal coliform bacteria.

The value for SQOLIM is derived from Horsley & Whitten 1986, where the following equation was used to represent surface die-off of fecal coliform bacteria:

$N_t = N_0(10^{-kt})$ where:
N_t = number of fecal coliforms at time t
N_0 = number of fecal coliforms at time 0
t = time in days
k = first order die-off rate constant. Typical values for warm months = 0.51/day and for cold months = 0.36/day

Using the above equation and assuming the die-off rates presented, the maximum buildup during warm months is approximately 1.5 x daily buildup rate and for colder months is 1.8 x daily buildup rate.
Assume that warmer months are April through September while colder months are October through March.

Assume a buildup limit of 1.8 x daily buildup rate for non-monthly varying SQOLIM.

CROPLAND

January

	ACQOP (#/acre/day)	SQOLIM (#/acre)
001	3.52E+07	6.33E+07
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

February

	ACQOP (#/acre/day)	SQOLIM (#/acre)
001	3.52E+07	6.33E+07
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

March

	ACQOP (#/acre/day)	SQOLIM (#/acre)
001	1.74E+08	3.14E+08
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

April

	ACQOP (#/acre/day)	SQOLIM (#/acre)
001	3.37E+08	5.06E+08
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

PASTURELAND

January

	ACQOP (#/acre/day)	SQOLIM (#/acre)
001	3.12E+10	5.62E+10
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

February

	ACQOP (#/acre/day)	SQOLIM (#/acre)
001	3.12E+10	5.62E+10
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

March

	ACQOP (#/acre/day)	SQOLIM (#/acre)
001	3.12E+10	5.62E+10
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

April

	ACQOP (#/acre/day)	SQOLIM (#/acre)
001	3.12E+10	4.69E+10
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

FOREST

All Months

	ACQOP (#/acre/day)	SQOLIM (#/acre)
001	3.52E+07	6.33E+07
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

BUILT-UP

All Months

	ACQOP (#/acre/day)	SQOLIM (#/acre)
001	9.04E+06	1.63E+07
P2	#DIV/0!	#DIV/0!
P3	#DIV/0!	#DIV/0!
P4	#DIV/0!	#DIV/0!
P5	#DIV/0!	#DIV/0!
P6	#DIV/0!	#DIV/0!
P7	#DIV/0!	#DIV/0!
P8	#DIV/0!	#DIV/0!
P9	#DIV/0!	#DIV/0!
P10	#DIV/0!	#DIV/0!

May

	ACQOP	SQOLIM
	(#/acre/day)	(#/acre)
001	2.83E+08	4.24E+08
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

June

	ACQOP	SQOLIM
	(#/acre/day)	(#/acre)
001	2.91E+08	4.37E+08
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

July

	ACQOP	SQOLIM
	(#/acre/day)	(#/acre)
001	2.83E+08	4.24E+08
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

August

	ACQOP	SQOLIM
	(#/acre/day)	(#/acre)
001	2.83E+08	4.24E+08
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

September

	ACQOP	SQOLIM
	(#/acre/day)	(#/acre)
001	3.39E+08	5.09E+08
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

October

	ACQOP	SQOLIM
	(#/acre/day)	(#/acre)
001	1.74E+08	3.14E+08
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00

November

	ACQOP	SQOLIM
	(#/acre/day)	(#/acre)
001	3.52E+07	6.33E+07
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

December

	ACQOP	SQOLIM
	(#/acre/day)	(#/acre)
001	3.52E+07	6.33E+07
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

May

	ACQOP	SQOLIM
	(#/acre/day)	(#/acre)
001	3.12E+10	4.69E+10
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

June

	ACQOP	SQOLIM
	(#/acre/day)	(#/acre)
001	3.12E+10	4.69E+10
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

July

	ACQOP	SQOLIM
	(#/acre/day)	(#/acre)
001	3.12E+10	4.69E+10
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

August

	ACQOP	SQOLIM
	(#/acre/day)	(#/acre)
001	3.12E+10	4.69E+10
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

September

	ACQOP	SQOLIM
	(#/acre/day)	(#/acre)
001	3.12E+10	4.69E+10
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

October

	ACQOP	SQOLIM
	(#/acre/day)	(#/acre)
001	3.12E+10	5.62E+10
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00

November

	ACQOP	SQOLIM
	(#/acre/day)	(#/acre)
001	3.12E+10	5.62E+10
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

December

	ACQOP	SQOLIM
	(#/acre/day)	(#/acre)
001	3.12E+10	5.62E+10
P2	0.00E+00	0.00E+00
P3	0.00E+00	0.00E+00
P4	0.00E+00	0.00E+00
P5	0.00E+00	0.00E+00
P6	0.00E+00	0.00E+00
P7	0.00E+00	0.00E+00
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00
P10	0.00E+00	0.00E+00

Total Maxiumum Daily Loads Evaluation (Fecal Coliform)
Mud Swamp Creek Watershed

Manure Application Loading
This sheet contains information relevant to land application of waste produced by agricultural animals in the study area.

Application of hog manure, beef cattle manure, dairy cattle manure, horse manure, poultry litter, and manure from import are considered.
Manure generated by in-subwatershed animals is assumed to be applied fresh (thus fecal content from fresh manure is used in calculations).
Manure values can be varied using a multiplication factor, in order to consider die-off due to known treatment/storage methods.
Manure imported into the subwatershed is assigned a fecal coliform content based on known storage/treatment methods.
The information is presented based on monthly variability of waste application.
It is assumed that cattle manure, poultry litter, and imported manure are applied to both Cropland and Pastureland. Hog manure is assumed to be applied only to cropland. Horse manure is assumed to be applied only to pasturel
note: the fecal die-off rates (fecal content multiplier) are assumed values, adjust accordingly
Hog Manure Available for Wash-off

Storage/treatment of manure prior to application may affect the fecal coliform content in the manure.
The multiplier below can be used to increase or decrease the fecal content in manure that is applied (to consider storage/treatment)
Manure fecal content multiplier 0.56

This is the fraction of the annual manure application that is applied each month.

	January	February	March	April	May	June	July	August	September	October	November	December
Fraction of manure applied each month	0	0	0.075	0.1575	0.1335	0.1335	0.1335	0.1335	0.1585	0.075	0	0

The fraction of manure available for runoff is dependent on the method of manure application. The fraction available is computed below based on incorporation into soil. These are assumed values.

Fraction incorporated into soil (assumed)	0.80		FRACTION AVAIL FOR RUNOFF =
Fraction available for runoff	0.60	0.336	NRCS RATE: 0.3354

The following is the resulting fraction of annual manure application available for runoff each month based on the monthly fraction applied and incorporation into the soil.

REACH ID	January	February	March	April	May	June	July	August	September	October	November	December
001	0	0	0.045	0.0945	0.0801	0.0801	0.0801	0.0801	0.0951	0.045	0	0
P2	0	0	0.045	0.0945	0.0801	0.0801	0.0801	0.0801	0.0951	0.045	0	0
P3	0	0	0.045	0.0945	0.0801	0.0801	0.0801	0.0801	0.0951	0.045	0	0
P4	0	0	0.045	0.0945	0.0801	0.0801	0.0801	0.0801	0.0951	0.045	0	0
P5	0	0	0.045	0.0945	0.0801	0.0801	0.0801	0.0801	0.0951	0.045	0	0
P6	0	0	0.045	0.0945	0.0801	0.0801	0.0801	0.0801	0.0951	0.045	0	0
P7	0	0	0.045	0.0945	0.0801	0.0801	0.0801	0.0801	0.0951	0.045	0	0
P8	0	0	0.045	0.0945	0.0801	0.0801	0.0801	0.0801	0.0951	0.045	0	0
P9	0	0	0.045	0.0945	0.0801	0.0801	0.0801	0.0801	0.0951	0.045	0	0
P10	0	0	0.045	0.0945	0.0801	0.0801	0.0801	0.0801	0.0951	0.045	0	0

Beef Cattle Manure Available for Wash-off

Storage/treatment of manure prior to application may affect the fecal coliform content in the manure.
The multiplier below can be used to increase or decrease the fecal content in manure that is applied (to consider storage/treatment)
Manure fecal content multiplier 0.0157 (a value of 1 assumes fresh application)

This is the fraction of the annual manure application that is applied each month.

	January	February	March	April	May	June	July	August	September	October	November	December
Fraction of manure applied each month	0.0833	0.0833	0.0833	0.0833	0.0833	0.0834	0.0834	0.0834	0.0834	0.0833	0.0833	0.0833

The fraction of manure available for runoff is dependent on the method of manure application. The fraction available is computed below based on incorporation into soil. These are assumed values.

Fraction incorporated into soil (assumed) 0.75 FRACTION AVAIL FOR RUNOFF =
Fraction available for runoff 0.63 0.0098125 NRCS RATE= 0.0098 (INCLUDES DIE OFF)

% Applied to Cropland: 0.75 % Applied to Pastureland: 0.25 1

The follow ing is the resulting fraction of annual manure application available for runoff each month based on the monthly fraction applied and incorporation into the soil.

REACH ID	January	February	March	April	May	June	July	August	September	October	November	December
001	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P2	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P3	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P4	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P5	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P6	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P7	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P8	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P9	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P10	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625

Horse Manure Available for Wash-off

Storage/treatment of manure prior to application may affect the fecal coliform content in the manure.
The multiplier below can be used to increase or decrease the fecal content in manure that is applied (to consider storage/treatment)

Manure fecal content multiplier	0.0194	(a value of 1 assumes fresh application)	0.02

This is the fraction of the annual manure application that is applied each month.

	January	February	March	April	May	June	July	August	September	October	November	December
Fraction of manure applied each month	0.0833	0.0833	0.0833	0.0833	0.0833	0.0834	0.0834	0.0834	0.0834	0.0833	0.0833	0.0833

The fraction of manure available for runoff is dependent on the method of manure application. The fraction available is computed below based on incorporation into soil. These are assumed values.

Fraction incorporated into soil (assumed)	0.75		FRACTION AVAILABLE FOR RUNOFF =
Fraction available for runoff	0.63	0.012125	NRCS VALUE = 0.0122 (INCLUDES DIE OFF)

The follow ing is the resulting fraction of annual manure application available for runoff each month based on the monthly fraction applied and incorporation into the soil.

REACH ID	January	February	March	April	May	June	July	August	September	October	November	December
001	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P2	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P3	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P4	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P5	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P6	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P7	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P8	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P9	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625
P10	0.0520625	0.0520625	0.0520625	0.0520625	0.0520625	0.052125	0.052125	0.052125	0.052125	0.0520625	0.0520625	0.0520625

Poultry Litter Available for Wash-off

Storage/treatment of manure prior to application may affect the fecal coliform content in the manure.
The multiplier below can be used to increase or decrease the fecal content in manure that is applied (to consider storage/treatment)

Manure fecal content multiplier	0.0138	(a value of 1 assumes fresh application)	0.29

This is the fraction of the annual litter application that is applied each month.

	January	February	March	April	May	June	July	August	September	October	November	December
Fraction of litter applied each month	0	0	0.075	0.1575	0.1335	0.1335	0.1335	0.1335	0.1585	0.075	0	0

The fraction of litter available for runoff is dependent on the method of litter application. The fraction available is computed below based on incorporation into soil. These are assumed values.

Fraction incorporated into soil (assumed)	0.96		FRACTION AVAILABLE FOR RUNOFF:	0.36
Fraction available for runoff	0.36	0.004968	NRCS VALUES : 0.2029 FOR LAYERS; 0.00496 FOR BROILERS	

% Applied to Cropland:	0.40	% Applied to Pastureland:	0.60	1

The follow ing is the resulting fraction of annual litter application available for runoff each month based on the monthly fraction applied and incorporation into the soil.

REACH ID	January	February	March	April	May	June	July	August	September	October	November	December
001	0	0	0.027	0.0567	0.04806	0.04806	0.04806	0.04806	0.05706	0.027	0	0
P2	0	0	0.027	0.0567	0.04806	0.04806	0.04806	0.04806	0.05706	0.027	0	0
P3	0	0	0.027	0.0567	0.04806	0.04806	0.04806	0.04806	0.05706	0.027	0	0
P4	0	0	0.027	0.0567	0.04806	0.04806	0.04806	0.04806	0.05706	0.027	0	0
P5	0	0	0.027	0.0567	0.04806	0.04806	0.04806	0.04806	0.05706	0.027	0	0
P6	0	0	0.027	0.0567	0.04806	0.04806	0.04806	0.04806	0.05706	0.027	0	0
P7	0	0	0.027	0.0567	0.04806	0.04806	0.04806	0.04806	0.05706	0.027	0	0
P8	0	0	0.027	0.0567	0.04806	0.04806	0.04806	0.04806	0.05706	0.027	0	0
P9	0	0	0.027	0.0567	0.04806	0.04806	0.04806	0.04806	0.05706	0.027	0	0
P10	0	0	0.027	0.0567	0.04806	0.04806	0.04806	0.04806	0.05706	0.027	0	0

Dairy Cattle Manure Available for Wash-off

Storage/treatment of manure prior to application may affect the fecal coliform content in the manure.
The multiplier below can be used to increase or decrease the fecal content in manure that is applied (to consider storage/treatment)

Manure fecal content multiplier 0.325 (a value of 1 assumes fresh application) 0.26

This is the fraction of the annual manure application that is applied each month.

	January	February	March	April	May	June	July	August	September	October	November	December
Fraction of manure applied each month	0	0.0835	0.075	0.1585	0.05	0.1335	0.05	0.1335	0.075	0.1585	0	0.0825

The fraction of manure available for runoff is dependent on the method of manure application. The fraction available is computed below based on incorporation into soil. These are assumed values.

Fraction incorporated into soil (assumed) 0.75 FRACTION AVAILABLE FOR RUNOFF:
Fraction available for runoff 0.63 0.203125 NRCS VALUES: 0.0965 GRAZING; 0.2048 CONFINED (FOR TMDL, ASSUME CONFINED CONDITIONS)

% Applied to Cropland: 0.75 % Applied to Pastureland: 0.25 1

The follow ing is the resulting fraction of annual manure application available for runoff each month based on the monthly fraction applied and incorporation into the soil.

REACH ID	January	February	March	April	May	June	July	August	September	October	November	December
001	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P2	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P3	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P4	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P5	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P6	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P7	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P8	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P9	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P10	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625

Imported Manure Available for Wash-off (Optional)

Significant amounts of manure imported into the study area for application to cropland or pastureland should be considered.
The amount of manure imported annually and the fecal coliform content in the manure must be designated.
See the References sheet for fecal coliform content in fresh manure from a variety of animals.

Estimated amount of imported manure annually (tons)	0
Amount of imported manure annually (lbs)	0.00E+00
Estimated fecal coliform content in imported manure (#/lb)	1.91E+09

This is the fraction of the annual manure application that is applied each month.

	January	February	March	April	May	June	July	August	September	October	November	December
Fraction of manure applied each month	0	0.0835	0.075	0.1585	0.05	0.1335	0.05	0.1335	0.075	0.1585	0	0.0825

The fraction of manure available for runoff is dependent on the method of manure application. The fraction available is computed below based on incorporation into soil. These are assumed values.

Fraction incorporated into soil (assumed)	0.75	
Fraction available for runoff	0.63	= (1 - [fraction incorporated]) + ([fraction incorporated] * 0.5)

% Applied to Cropland:	0.75	% Applied to Pastureland:	0.25	**1**

The following is the resulting fraction of annual manure application available for runoff each month based on the monthly fraction applied and incorporation into the soil.

REACH ID	January	February	March	April	May	June	July	August	September	October	November	December
001	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P2	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P3	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P4	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P5	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P6	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P7	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P8	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P9	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625
P10	0	0.0521875	0.046875	0.0990625	0.03125	0.0834375	0.03125	0.0834375	0.046875	0.0990625	0	0.0515625

Total Maximum Daily Load Evaluation (Fecal Coliform)
Mud Swamp Creek Watershed

Cattle Stream Access Loading
This sheet contains information related to the direct contribution of cattle fecal coliform bacteria to streams.
The direct contribution of fecal coliform from cattle to a stream can be represented as a direct source in the model. Required input for direct sources in NPSM are flow (cfs) and loading rate (#/hr).

It is assumed that only beef cattle are grazing and therefore have access to streams. They have access to streams based on information in the Cattle Farming worksheet.

Assume the following:

Beef Cattle Waste: 46 (lbs/animal/day)
The density of cattle manure (including urine) is approximately the density of water: 62.4 (lbs/cubic foot)

CATTLE AS A DIRECT SOURCE

January	# grazing beef cattle	# grazing dairy cattle	# beef cattle in streams	# dairy cattle in streams	FC Loading Rate (#/hr)	Waste Flow (cfs)
001	152	0	0.039	0.000	1.68E+08	3.33E-07
P2	0	0	0.000	0.000	0.00E+00	0.00E+00
P3	0	0	0.000	0.000	0.00E+00	0.00E+00
P4	0	0	0.000	0.000	0.00E+00	0.00E+00
P5	0	0	0.000	0.000	0.00E+00	0.00E+00
P6	0	0	0.000	0.000	0.00E+00	0.00E+00
P7	0	0	0.000	0.000	0.00E+00	0.00E+00
P8	0	0	0.000	0.000	0.00E+00	0.00E+00
P9	0	0	0.000	0.000	0.00E+00	0.00E+00
P10	0	0	0.000	0.000	0.00E+00	0.00E+00

February	# grazing beef cattle	# grazing dairy cattle	# beef cattle in streams	# dairy cattle in streams	FC Loading Rate (#/hr)	Waste Flow (cfs)
001	152	0	0.039	0.000	1.68E+08	3.33E-07
P2	0	0	0.000	0.000	0.00E+00	0.00E+00
P3	0	0	0.000	0.000	0.00E+00	0.00E+00
P4	0	0	0.000	0.000	0.00E+00	0.00E+00
P5	0	0	0.000	0.000	0.00E+00	0.00E+00
P6	0	0	0.000	0.000	0.00E+00	0.00E+00
P7	0	0	0.000	0.000	0.00E+00	0.00E+00
P8	0	0	0.000	0.000	0.00E+00	0.00E+00
P9	0	0	0.000	0.000	0.00E+00	0.00E+00
P10	0	0	0.000	0.000	0.00E+00	0.00E+00

March	# grazing beef cattle	# grazing dairy cattle	# beef cattle in streams	# dairy cattle in streams	FC Loading Rate (#/hr)	Waste Flow (cfs)
001	152	0	0.039	0.000	1.68E+08	3.33E-07
P2	0	0	0.000	0.000	0.00E+00	0.00E+00
P3	0	0	0.000	0.000	0.00E+00	0.00E+00
P4	0	0	0.000	0.000	0.00E+00	0.00E+00
P5	0	0	0.000	0.000	0.00E+00	0.00E+00
P6	0	0	0.000	0.000	0.00E+00	0.00E+00
P7	0	0	0.000	0.000	0.00E+00	0.00E+00
P8	0	0	0.000	0.000	0.00E+00	0.00E+00
P9	0	0	0.000	0.000	0.00E+00	0.00E+00
P10	0	0	0.000	0.000	0.00E+00	0.00E+00

April	# grazing beef cattle	# grazing dairy cattle	# beef cattle in streams	# dairy cattle in streams	FC Loading Rate (#/hr)	Waste Flow (cfs)
001	152	0	0.039	0.000	1.68E+08	3.33E-07
P2	0	0	0.000	0.000	0.00E+00	0.00E+00
P3	0	0	0.000	0.000	0.00E+00	0.00E+00
P4	0	0	0.000	0.000	0.00E+00	0.00E+00
P5	0	0	0.000	0.000	0.00E+00	0.00E+00
P6	0	0	0.000	0.000	0.00E+00	0.00E+00
P7	0	0	0.000	0.000	0.00E+00	0.00E+00
P8	0	0	0.000	0.000	0.00E+00	0.00E+00
P9	0	0	0.000	0.000	0.00E+00	0.00E+00
P10	0	0	0.000	0.000	0.00E+00	0.00E+00

May	# grazing beef cattle	# grazing dairy cattle	# beef cattle in streams	# dairy cattle in streams	FC Loading Rate (#/hr)	Waste Flow (cfs)
001	152	0	0.039	0.000	1.68E+08	3.33E-07
P2	0	0	0.000	0.000	0.00E+00	0.00E+00
P3	0	0	0.000	0.000	0.00E+00	0.00E+00
P4	0	0	0.000	0.000	0.00E+00	0.00E+00
P5	0	0	0.000	0.000	0.00E+00	0.00E+00
P6	0	0	0.000	0.000	0.00E+00	0.00E+00
P7	0	0	0.000	0.000	0.00E+00	0.00E+00
P8	0	0	0.000	0.000	0.00E+00	0.00E+00
P9	0	0	0.000	0.000	0.00E+00	0.00E+00
P10	0	0	0.000	0.000	0.00E+00	0.00E+00

June	# grazing beef cattle	# grazing dairy cattle	# beef cattle in streams	# dairy cattle in streams	FC Loading Rate (#/hr)	Waste Flow (cfs)
001	152	0	0.039	0.000	1.68E+08	3.33E-07
P2	0	0	0.000	0.000	0.00E+00	0.00E+00
P3	0	0	0.000	0.000	0.00E+00	0.00E+00
P4	0	0	0.000	0.000	0.00E+00	0.00E+00
P5	0	0	0.000	0.000	0.00E+00	0.00E+00
P6	0	0	0.000	0.000	0.00E+00	0.00E+00
P7	0	0	0.000	0.000	0.00E+00	0.00E+00
P8	0	0	0.000	0.000	0.00E+00	0.00E+00
P9	0	0	0.000	0.000	0.00E+00	0.00E+00
P10	0	0	0.000	0.000	0.00E+00	0.00E+00

July	# grazing beef cattle	# grazing dairy cattle	# beef cattle in streams	# dairy cattle in streams	FC Loading Rate (#/hr)	Waste Flow (cfs)
001	152	0	0.039	0.000	1.68E+08	3.33E-07
P2	0	0	0.000	0.000	0.00E+00	0.00E+00
P3	0	0	0.000	0.000	0.00E+00	0.00E+00
P4	0	0	0.000	0.000	0.00E+00	0.00E+00
P5	0	0	0.000	0.000	0.00E+00	0.00E+00
P6	0	0	0.000	0.000	0.00E+00	0.00E+00
P7	0	0	0.000	0.000	0.00E+00	0.00E+00
P8	0	0	0.000	0.000	0.00E+00	0.00E+00
P9	0	0	0.000	0.000	0.00E+00	0.00E+00
P10	0	0	0.000	0.000	0.00E+00	0.00E+00

August	# grazing beef cattle	# grazing dairy cattle	# beef cattle in streams	# dairy cattle in streams	FC Loading Rate (#/hr)	Waste Flow (cfs)
001	152	0	0.039	0.000	1.68E+08	3.33E-07
P2	0	0	0.000	0.000	0.00E+00	0.00E+00
P3	0	0	0.000	0.000	0.00E+00	0.00E+00
P4	0	0	0.000	0.000	0.00E+00	0.00E+00
P5	0	0	0.000	0.000	0.00E+00	0.00E+00
P6	0	0	0.000	0.000	0.00E+00	0.00E+00
P7	0	0	0.000	0.000	0.00E+00	0.00E+00
P8	0	0	0.000	0.000	0.00E+00	0.00E+00
P9	0	0	0.000	0.000	0.00E+00	0.00E+00
P10	0	0	0.000	0.000	0.00E+00	0.00E+00

September	# grazing beef cattle	# grazing dairy cattle	# beef cattle in streams	# dairy cattle in streams	FC Loading Rate (#/hr)	Waste Flow (cfs)
001	152	0	0.039	0.000	1.68E+08	3.33E-07
P2	0	0	0.000	0.000	0.00E+00	0.00E+00
P3	0	0	0.000	0.000	0.00E+00	0.00E+00
P4	0	0	0.000	0.000	0.00E+00	0.00E+00
P5	0	0	0.000	0.000	0.00E+00	0.00E+00
P6	0	0	0.000	0.000	0.00E+00	0.00E+00
P7	0	0	0.000	0.000	0.00E+00	0.00E+00
P8	0	0	0.000	0.000	0.00E+00	0.00E+00
P9	0	0	0.000	0.000	0.00E+00	0.00E+00
P10	0	0	0.000	0.000	0.00E+00	0.00E+00

October	# grazing beef cattle	# grazing dairy cattle	# beef cattle in streams	# dairy cattle in streams	FC Loading Rate (#/hr)	Waste Flow (cfs)
001	152	0	0.039	0.000	1.68E+08	3.33E-07
P2	0	0	0.000	0.000	0.00E+00	0.00E+00
P3	0	0	0.000	0.000	0.00E+00	0.00E+00
P4	0	0	0.000	0.000	0.00E+00	0.00E+00
P5	0	0	0.000	0.000	0.00E+00	0.00E+00
P6	0	0	0.000	0.000	0.00E+00	0.00E+00
P7	0	0	0.000	0.000	0.00E+00	0.00E+00
P8	0	0	0.000	0.000	0.00E+00	0.00E+00
P9	0	0	0.000	0.000	0.00E+00	0.00E+00
P10	0	0	0.000	0.000	0.00E+00	0.00E+00

November	# grazing beef cattle	# grazing dairy cattle	# beef cattle in streams	# dairy cattle in streams	FC Loading Rate (#/hr)	Waste Flow (cfs)
001	152	0	0.039	0.000	1.68E+08	3.33E-07
P2	0	0	0.000	0.000	0.00E+00	0.00E+00
P3	0	0	0.000	0.000	0.00E+00	0.00E+00
P4	0	0	0.000	0.000	0.00E+00	0.00E+00
P5	0	0	0.000	0.000	0.00E+00	0.00E+00
P6	0	0	0.000	0.000	0.00E+00	0.00E+00
P7	0	0	0.000	0.000	0.00E+00	0.00E+00
P8	0	0	0.000	0.000	0.00E+00	0.00E+00
P9	0	0	0.000	0.000	0.00E+00	0.00E+00
P10	0	0	0.000	0.000	0.00E+00	0.00E+00

December	# grazing beef cattle	# grazing dairy cattle	# beef cattle in streams	# dairy cattle in streams	FC Loading Rate (#/hr)	Waste Flow (cfs)
001	152	0	0.039	0.000	1.68E+08	3.33E-07
P2	0	0	0.000	0.000	0.00E+00	0.00E+00
P3	0	0	0.000	0.000	0.00E+00	0.00E+00
P4	0	0	0.000	0.000	0.00E+00	0.00E+00
P5	0	0	0.000	0.000	0.00E+00	0.00E+00
P6	0	0	0.000	0.000	0.00E+00	0.00E+00
P7	0	0	0.000	0.000	0.00E+00	0.00E+00
P8	0	0	0.000	0.000	0.00E+00	0.00E+00
P9	0	0	0.000	0.000	0.00E+00	0.00E+00
P10	0	0	0.000	0.000	0.00E+00	0.00E+00

Total Maximum Daily Load Evaluation (Fecal Coliform)
Mud Swamp Creek Watershed

Septic System Loading

This sheet contains information related to the contribution of failing septic systems to streams.

The direct contribution of fecal coliform from septics to a stream can be represented as a point source in the model. Required input for point sources in NI

The following assumptions are made for septic contributions.

Assume a failure rate for septics in the watershed: 20 %

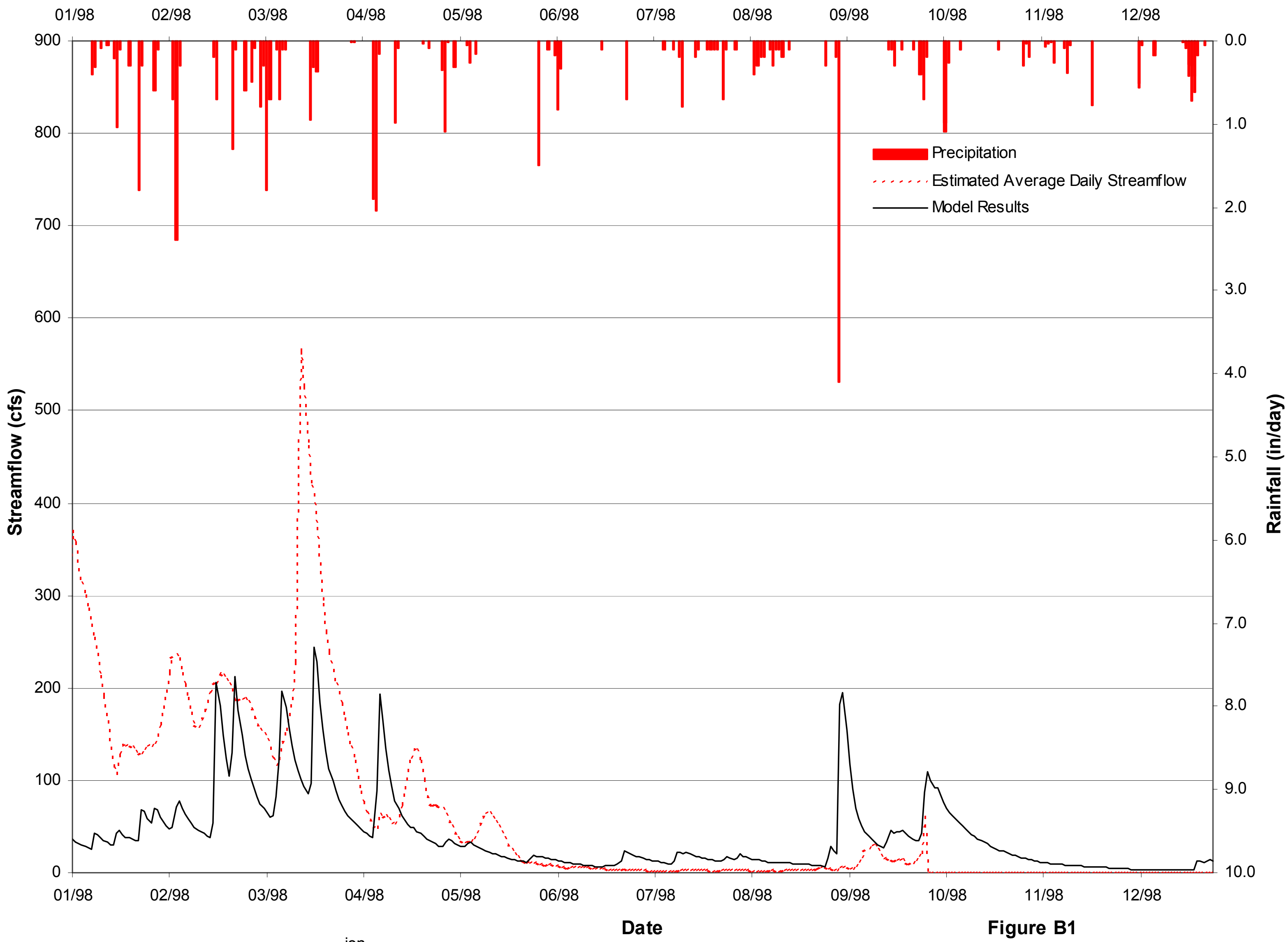
Assume the average FC concentration reaching the stream (from septic overcharge) is: 1.00E+04 #/100 ml **(Horsely & Whitten, 1996)**
Assume a typical septic overcharge flow rate of: 70 gal/day/person **(Horsely & Whitten, 1996)**

SEPTICS AS A POINT SOURCE

Subwatershed	Tot. # people in watershed	WCS Tot. # people on septics	Density people/septic	# failing septics	Tot. # people served	Septic flow (gal/day)	Septic flow (mL/hr)	FC rate (#/hr)	Septic flow (cfs)
001	15000	**2469**	2.37	208.4	493.8	34566	5,451,346	5.45E+08	5.36E-02
P2			2.37	0.0	0.0	0	0	0.00E+00	0.00E+00
P3			2.37	0.0	0.0	0	0	0.00E+00	0.00E+00
P4			2.37	0.0	0.0	0	0	0.00E+00	0.00E+00
P5			2.37	0.0	0.0	0	0	0.00E+00	0.00E+00
P6			2.37	0.0	0.0	0	0	0.00E+00	0.00E+00
P7			2.37	0.0	0.0	0	0	0.00E+00	0.00E+00
P8			2.37	0.0	0.0	0	0	0.00E+00	0.00E+00
P9			2.37	0.0	0.0	0	0	0.00E+00	0.00E+00
P10		0	0	0.0	0.0	0	0	0.00E+00	0.00E+00
Total:		2,469							

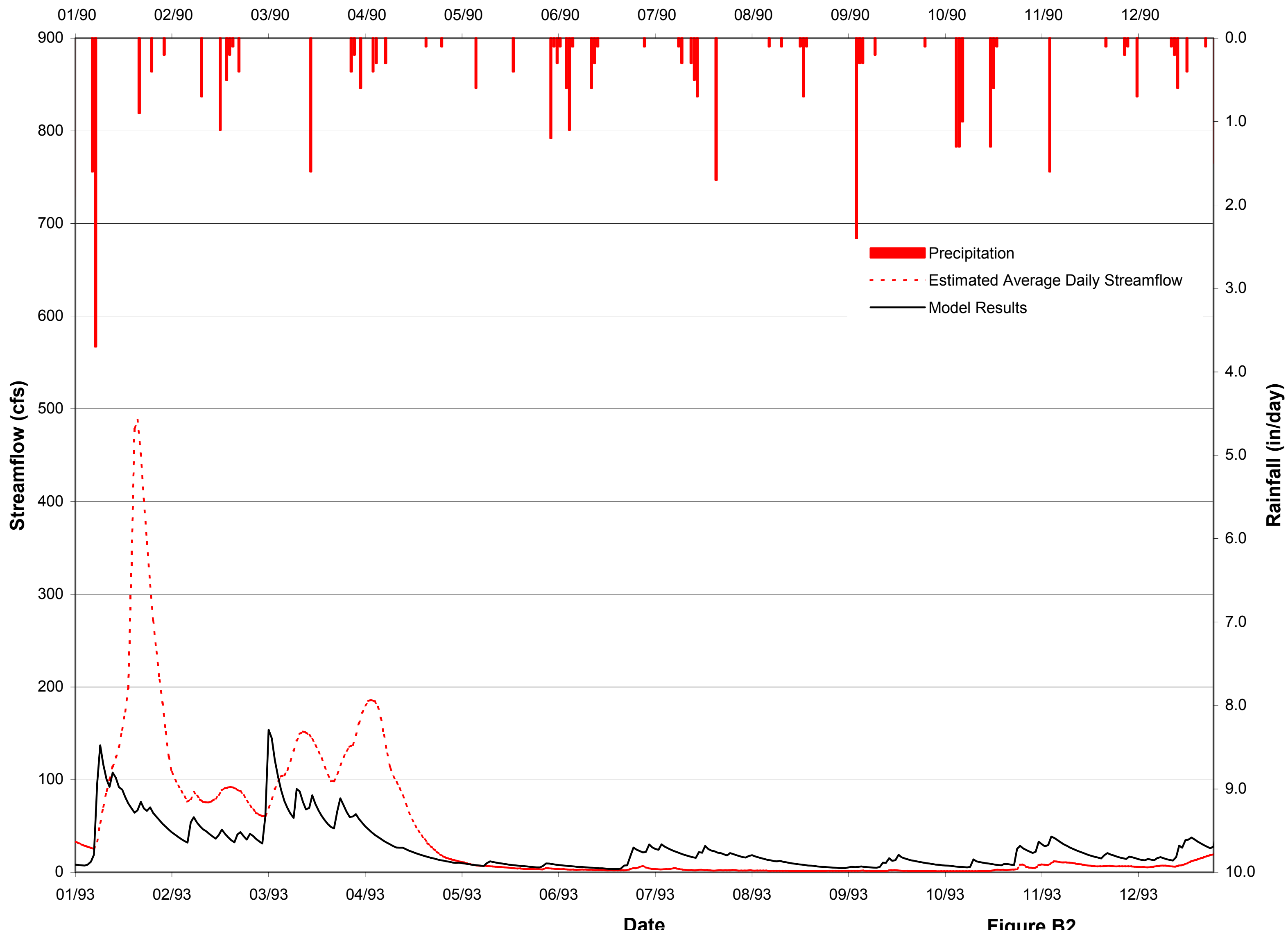
APPENDIX B

Hydrologic and Water Quality Model Calibration



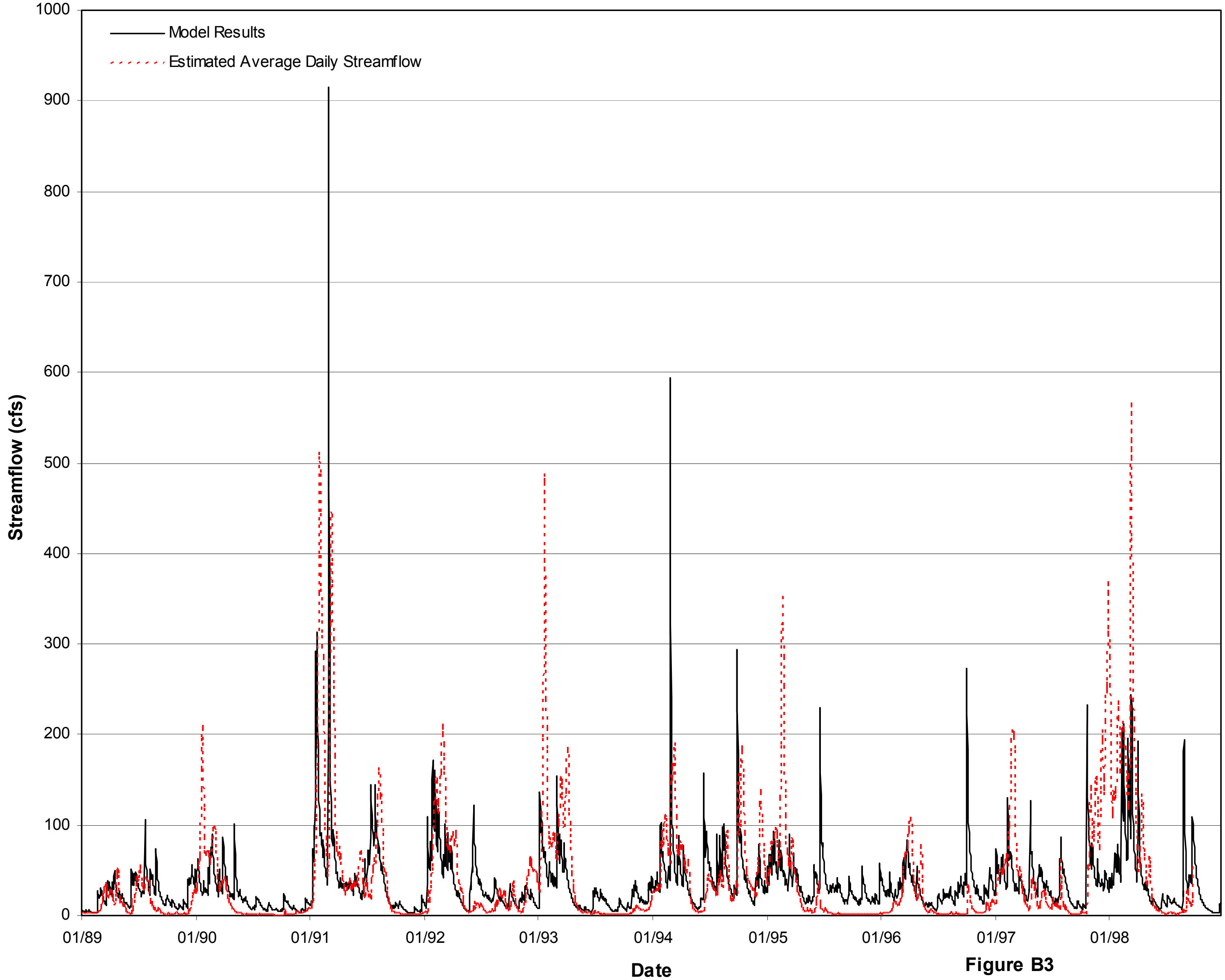
ion

Figure B1
Mud Swamp Creek Hydrologic Model Calibration
1998 Calibration



Georgia Environmental Protection Division
Atlanta, Georgia

Figure B2
Mud Swamp Creek Hydrologic Model Calibration
1993 Critical Conditions



sion

Figure B3
Mud Swamp Creek
Simulation Period Streamflow Hydrograph

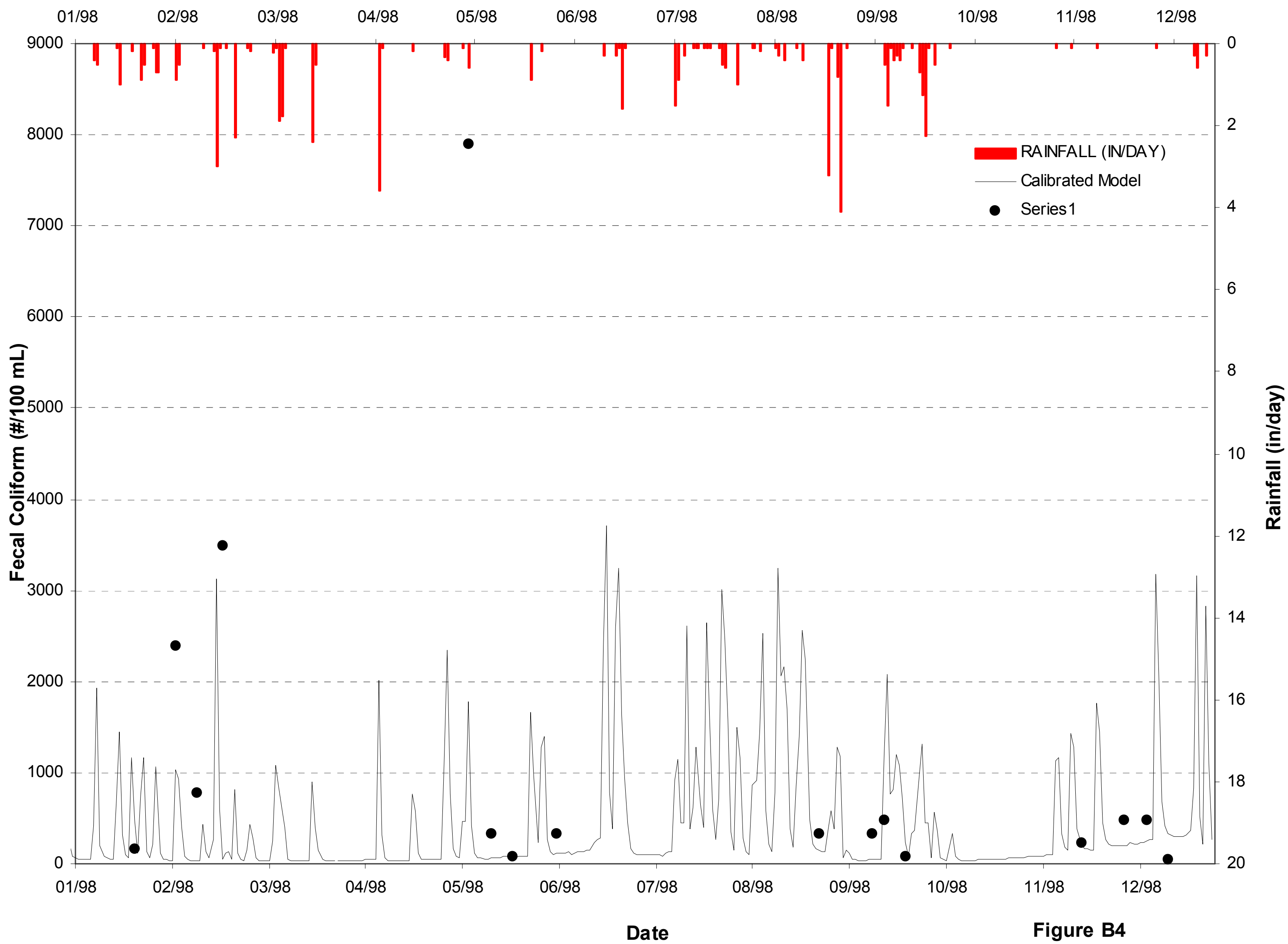


Figure B4
Mud Swamp Creek
Fecal Coliform Water Quality Calibration

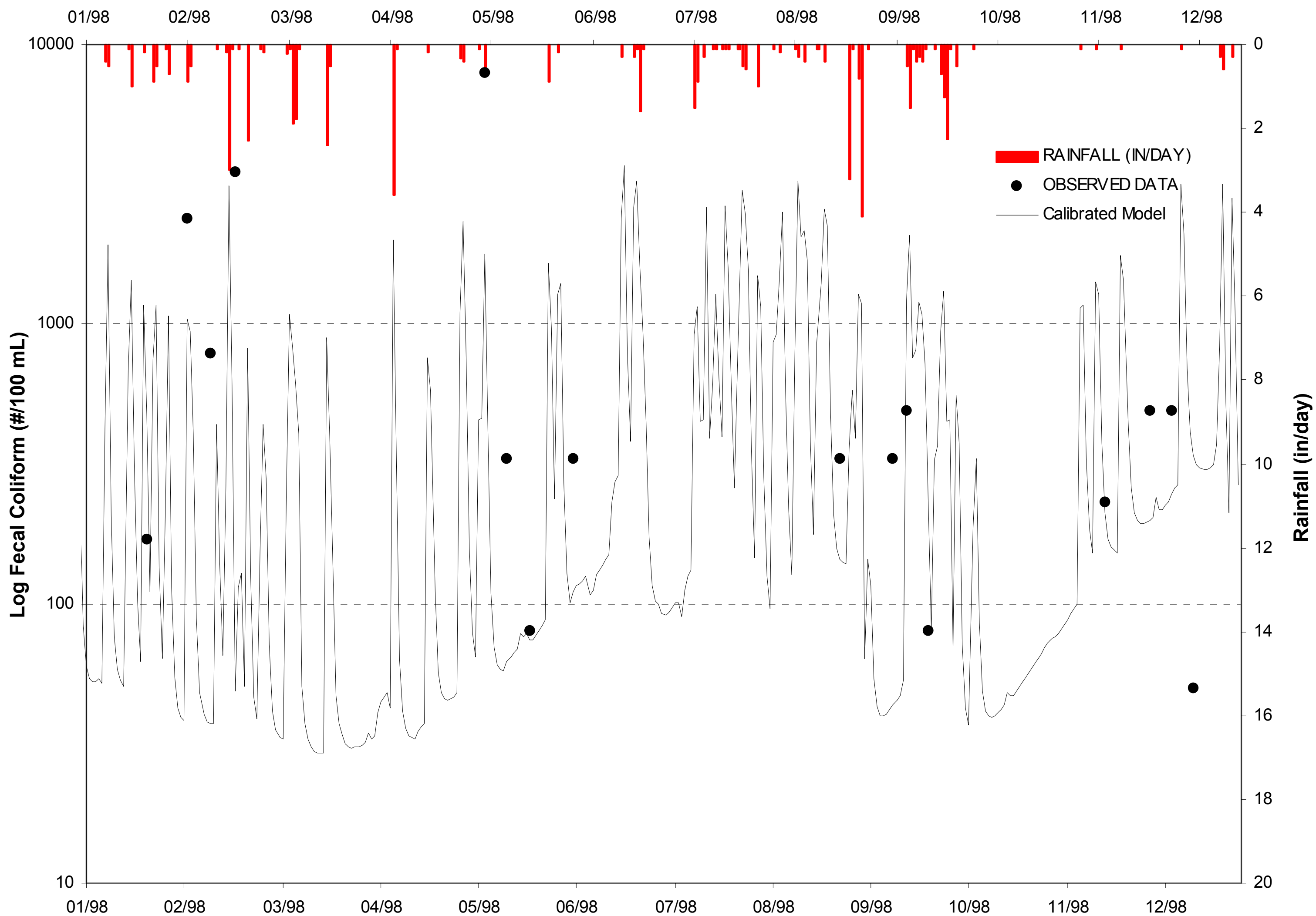


Figure B5
Mud Swamp Creek
Fecal Coliform Water Quality Calibration

APPENDIX C

Total Maximum Daily Load
Summary Memorandum

SUMMARY MEMORANDUM
Total Maximum Daily Load (TMDL)
Mud Swamp Creek

1. 303(d) Listed Waterbody Information

State:	**Georgia**
County:	**Lowndes**
Major River Basin:	**Suwannee**
8-Digit Hydrologic Unit Code(s):	**03110202**
Waterbody Name:	**Mud Swamp Creek**
Location:	**Downstream of Valdosta to Alapahoochee River**
Stream Length:	**10 miles**
Watershed Area:	**43 square miles**
Tributary to:	**Alapahoochee River**
Constituent(s) of Concern:	**Fecal Coliform Bacteria**
Designated Use:	**Fishing (not supporting designated use)**

Applicable Water Quality Standard:

May through October fecal coliform not to exceed a geometric mean of 200 per 100 ml based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours. For the months of November through April, fecal coliform not to exceed a geometric mean of 1,000 per 100 ml based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours and not to exceed a maximum of 4,000 per 100 ml for any sample.

2. TMDL Development

Constituent(s): Fecal Coliform Bacteria

Analysis/Modeling:

The Non-Point Source Model (NPSM)/Hydrologic Simulation Program Fortran (HSPF) was used to develop this TMDL. A daily time step was used to simulate hydrologic and water quality conditions. The model was developed for the entire watershed upstream from the 303(d) listed segment.

Critical Conditions:

A simulation period of 10 years was used to assess the water quality standards for this TMDL. This period represents a range of hydrologic and meteorological conditions.

Seasonal Variation:

A simulation period of 10 years was used to assess the water quality standards for this TMDL. This period represents a range of hydrologic and meteorological conditions including seasonal variations.

3. **Allocation Watershed/Stream Reach:**

Wasteload Allocations (WLA): **7.33×10^{11} counts/30 days**

Note: All future permitted discharges shall meet the water quality standard for fecal coliform bacteria of 200/100 ml as a geometric mean.

Valdosta WPCP - **7.33×10^{11} counts/30 days**

Load Allocation (LA): **5.98×10^{11} counts/30 days**

Margin of Safety (MOS):
The assumptions used in the parameterization of the water quality model were considered conservative enough to constitute an implicit margin of safety.

Total Maximum Daily Load (TMDL): **1.33×10^{12} counts/30 days**